Autosegmental Aims in Surface Optimizing Phonology

Stephanie S Shih
University of California, Merced
shih@ucmerced.edu

Sharon Inkelas
University of California, Berkeley
inkelas@berkeley.edu

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We develop a novel optimization approach to tone. Its grammatical component consists of the similarity- and proximity-based correspondence constraint framework of Agreement by Correspondence theory (ABC). Its representational component (Q theory) decomposes segments (*Q*) into temporally ordered, quantized subsegments (*q*), which comprise unitary sets of distinctive features, including tone. ABC+Q unites phonological alternations and static lexical patterns, as illustrated with a programmatic survey of core tonal phenomena: assimilation, dissimilation, lexical tone melodies, and consonant-tone interaction. ABC+Q surmounts long-standing problems for autosegmental-era, multi-tiered representational approaches to tone, and unites tone and segmental phonology under the modern umbrella of correspondence theory.

Keywords: tone, phonology, Agreement by Correspondence, Q Theory, Autosegmental Phonology, Optimality Theory

1 INTRODUCTION

On the grounds that "tone is like segmental phonology in every way—only more so!" (Hyman 2011:214), tone is an excellent testing ground for new theoretical developments within phonology. Capturing tonal behavior was a key factor in the development of Autosegmental Phonology (AP), which revolutionized the approach to rules and representations in the 1970's (e.g., Leben 1973a; Goldsmith 1976, 1979; Williams 1976). AP embodies two central claims: (a) different types of representations exist on independent tiers, organized by a central timing skeleton; and (b) the association between elements on featural tiers and elements on the timing tier can be one-to-one, one-to-many, many-to-one or even zero-to-one in the case of floating features or featurally underspecified timing units. AP was originally developed to handle suprasegmental phenomena (tone and pitch accent), but quickly was extended to segmental phenomena (vowel harmony, nasal harmony, consonant harmony).

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In the 1990's and the present century to date, the shift from rule-based phonology to surface-oriented optimization (Optimality Theory; OT) has challenged the need for rules and decreased the role of non-surface representations (Prince and Smolensky 1993; McCarthy and Prince 1995; et seq.). This sea change in phonological analysis has advanced our understanding of certain phenomena considerably. For example, stress assignment and syllabification are better captured as an exercise in 'best fit', rather than as a series of ordered rules. In the segmental arena, work in Agreement by Correspondence (ABC) has shown that assimilation, dissimilation and general phonotactic phenomena previously addressed using complex representations in AP are more insightfully analyzed using principles of phonological similarity that make no reference to tiers or association lines (e.g., Walker 2000; Hansson 2001, 2010; Rose and Walker 2004; Bennett 2013). From ABC, we have gained the insight that ill-formed, unstable correspondences are at the root of numerous diverse segmental repairs (e.g., Wayment 2009; Inkelas and Shih 2014).

As intellectually rewarding as this surface-oriented optimization development has been, it has largely bypassed the realm of tone. Some analyses in the tone literature have replaced rules with optimality-theoretic constraints, but even these generally use the same autosegmental representations for tone that were in force in the 1970's (see e.g., Myers 1997; Bickmore 1999; Akinlabi and Mutaka 2001; Akinlabi and Liberman 2001, 2006; Zoll 2003; Jenks and Rose 2011; Marlo et al. 2014). A rare mention of the possibility of replacing autosegmental tonal representations is found in Zoll 2003:fn. 16. Tone, as Hyman (2011) remarks, is still perceived as conceptually different from other features; stuck in the autosegmental era, it is no longer in the vanguard of phonological theory development.

In this paper, we call for a new rethinking of the way phonologists approach tone. Despite the appeal and persistence of autosegmental representations, we argue that the ABC framework offers a superior alternative to Autosegmental Phonology: ABC does as well or better at capturing the key behaviors that distinguish tone, and does not require the specialized autosegmental representations that have been abandoned in most domains other than tone.

We also argue that tone is one of the key sources of evidence for adopting a specific version of ABC which Shih & Inkelas (2014) have termed "ABC+Q", in which segments are represented as consisting of an ordered array of featurally specified subsegments. Related conceptually to both the Aperture complexes of Steriade 1993, 1994 and the tonal complexes of Akinlabi and Liberman 2001, Q theory revolutionizes the representation of contour segments and contour tones; it takes over much of the work that AP ascribed to the many-to-one linking properties of autosegments. With ABC handling the work that one-to-many correspondence did in AP, ABC+Q thus weakens or eliminates the need for autosegmental representations. In transitioning from AP to ABC+Q, we escape various problems of formal ambiguity and representational inconsistencies that have been periodically pointed out for AP (e.g., McCarthy 1989 on the question of consonant and vowel tiers; Hayes 1990 on diphthongization; Coleman and Local 1991 on the formal geometry of association lines; and Archangeli and Pulleyblank 1994; Gafos 1998 on the validity of gapped structures in the analysis of transparent segments, among many others).

We begin with a brief overview of ABC+Q, then sketch the key properties of tonal patterning that need to be captured in any theoretical framework and which are captured in ABC+Q, arguably better than in AP. For a more comprehensive review of tone languages, and of the basic ABC framework and its extensions, we refer the reader to the rich independent literature on these topics.[1]

2 ABC+Q

ABC+Q is a two-part theory, with a representational component (Q theory) and a constraint-based optimization component (Agreement by Correspondence) which emphasizes the role of surface-oriented output optimization. This section presents the representational component Q Theory, §2.1), the optimization component (ABC, §2.2), and a brief illustration of how the two work together in tonal phonology (§2.3).

2.1 Q THEORY

Since the beginning of classic generative phonology (e.g., Chomsky and Halle 1968), a null hypothesis of phonological representation has been that the speech stream is a temporal sequence of discrete units at different levels of granularity, the smallest of which is the segment. Autosegmental Phonology arose, in part, in response to challenges posed for this view by tone, for which the segment appeared to be too coarse to function as the basic unit of analysis. The AP solution was to posit segment-internal complexity via the additional representational apparatus of linking lines. Q theory, as outlined here, returns to the classic null hypothesis of units sequenced in time, but increases the granularity of units that the grammar can reference. Under Q theory, each segment (*Q*) is subdivided into temporally-ordered, quantized subsegments: *q*, as shown in (1).

(1) a. Q → Q (q^1 q^2 q^3)
b. ǎ` → V(à á à) (e.g., Mende *mbǎ`* ‘companion’) Leben 1978
c. e̯ai̯ → V(e̯ a i̯) (e.g., Romanian *cite̯ai̯* ‘read.IND.IMPF.2SG’) Dindelegan 2013
d. ⁿdz → C(n d z) (prenasalized affricate)

This tripartite subdivision is hypothesized on the basis that tonal contours and contour segments typically require no more than three subparts, roughly corresponding to phonetically-grounded, segment-internal landmarks of onset, target, and release. For vowels, a tripartite structure allows for the representation of triphthongs. For consonants,

[1] On ABC, see e.g., Hansson 2001; 2010a; Rose and Walker 2004; Rhodes 2010; Bennett 2013; etc. On ABC+Q, see e.g., Shih and Inkelas 2014. On tone, see e.g., Pulleyblank 1986; Yip 2002; Hyman 2011; amongst many others.

it permits the specification both of pre-closure features (e.g. preaspiration) as well as release features. For tone, the subdivided representation allows for syllable-internal contrasts in tone contour transition points, as found in Dinka, which contrasts an early-transition 'Low-fall' with a late-transition 'Fall' (Remijsen 2013). In Q theory, this corresponds to the difference between (H1 L2 L3) versus (H1 H2 L3). Similar alignment contrasts have also been invoked for Shilluk (Remijsen and Ayoker 2014) and certain German dialects (e.g., Gussenhoven and Peters 2004:277).

Q theory predicts that tone contours longer than three tones (and contour segments longer than three parts) will not occur. Certainly, 4-tone contours are typologically rare (e.g., Qiyang: see Hu 2011; or Korean *aegyo* markers: Moon, in prep). In some, if not all cases, four-tone contours are accompanied by obligatory lengthening of the segment via the co-opting of additional subsegments (Gordon 2001; Zhang 2001, 2004; a.o.). For contour segments like diphthongs, triphthongs, affricates, etc., this prediction also appears to be correct, with the possible exception of the apparently 4-part Mazatec [^{n}tʃ^{h}] (Pike and Pike 1947; Steriade 1994). See, however, Golston and Kehrein 1998 for an alternative analysis of Mazatec that does not posit a 4-part segment. The upper bound of three *q*'s is an architectural plank of ABC+Q, motivated by maximal onset-target-offset partitioning of segments that is independently supported in the segmental domain. AP, on the other hand, offers greater freedom of association between tones and tone bearing units, which comes at the cost of predicting potentially unbounded tonal contours.

It remains an open issue as to whether the number of segmental subdivisions remains consistent across all segments (i.e., three *q* per *Q*), or whether subdivisions are posited only in case of phonetic or phonological evidence. In general, we assume tripartite structures for this paper, though for graphical ease, we depict bipartite structures in several of the tableaux. For a fuller discussion of the design and predictions of Q theory, see e.g., Shih and Inkelas 2014.

Q theory exhibits multiple points of contact with Autosegmental Theory (Leben 1973a; Goldsmith 1976; et seq.), Articulatory Phonology (Browman and Goldstein 1989, et seq. Gafos 2002; a.o.), Aperture Theory (Steriade 1993, 1994), and proposals for multiple docking sites on tone-bearing units (e.g., Morén and Zsiga 2006). There are, however, a number of differences between Q theory and these predecessors.

Like Aperture Theory and Articulatory Phonology, Q theory posits phonetically-grounded temporal subdivisions with different featural makeup for (some) segments. In Aperture Theory, however, only stop consonants are subdivided, and they are subdivided into only two parts, as opposed to the three subdivisions all segments have in Q theory:

(2)		Aperture theory	cf. Q theory
	[t^h]	$\begin{matrix} A_0 & A_{rel} \\ \vert & \vert \\ t & h \end{matrix}$	Q(t^1 t^2 h^3)
	[s]	A_{fric}	Q(s^1 s^2 s^3)

Unlike Aperture Theory, Q theory explicitly includes tone as well as segmental features. In Q theory, the notion of 'segment' is explicit (the *Q* of Q(q^1 q^2 q^3)), while in Aperture Theory, 'segment' is not represented directly, but is the interpretation of a series of A positions. This distinction is important because, as is argued below, reference to the segment as a whole is crucial to capturing contour behavior.

Like Autosegmental Theory, Q theory allows independent, sequenced feature values within a single segment. Unlike Autosegmental Theory, however, Q theory treats tone as a featural attribute of each of these minimal temporal units *q*, while the actual grammatical domain of tone constraints—a concept which past literature has sometimes packed into the representational notion of a "tone-bearing unit" (TBU)—can be larger. If all of the *q* subsegments of a single *Q* segment agree in tone (e.g., (H1 H2 H3)), then as shorthand, it can be stated that the *Q* has H tone. The autosegmental insight that remains in Q theory, embedded within ABC, is the ability to reference a feature specification independent of others on the same timing unit: this is done via feature-specific constraints in the output-oriented constraint-based portion of ABC+Q, to which we now turn.

2.2 ABC

In ABC+Q, operations that AP handled with representational spreading, linking, and delinking are instead handled via markedness, faithfulness, and surface correspondences.[2] Agreement by Correspondence (ABC) was originally developed to account for long distance consonant harmony (e.g., Walker 2000; Hansson 2001; 2010a; Rose and Walker 2004), but its utility has since been extended to the domains of vowel harmony (e.g., Sasa 2009; Walker 2009; 2014; Rhodes 2012), dissimilation (Bennett 2013; 2014; 2015), local segmental processes (e.g., Wayment 2009; Inkelas and Shih 2014; Sylak-Glassman et al. 2014), and subsegmental harmonies (e.g., Shih and Inkelas 2014; Lionnet 2014). ABC can be seen as a radical deconstruction of the idea that assimilation—either local or long-distance—should be accomplished not via operational spreading (e.g., Ní Chiosáin and Padgett 2001) but rather via syntagmatic agreement constraints (for recent examples, see e.g. Baković 2000; Yu 2005; among many others). ABC is also related to the use of correspondence (and identity) to accomplish reduplication (see e.g., McCarthy and Prince 1995; Zuraw 2002).

The key insight in ABC is that more similar and proximal units are more likely to interact. Correspondence relationships between featurally and structurally similar and proximal units are mandated by sets of CORR constraints, for example:[3]

[2] In Author (in prep), we argue also for underlying correspondences built on the same string-to-string principles as surface correspondences.

[3] In more recent incarnations of ABC, correspondence and correspondence limiters are no longer modeled using two separate constraints. For example, Hansson 2014 proposes that a single conditional markedness constraint specifies the projected correspondence in addition to any limitations placed on the correspondence relationship. For consistency with the majority of the ABC literature, we use the legacy ABC formulation here to illustrate examples; the basic insights and mechanisms afforded by ABC are the same whether the original CORR constraints or their updated counterparts are used.

(3) a. CORR-X::X — Assess a violation for every consecutive, immediately adjacent pair of X and X that are not in a surface correspondence relationship, where X is a *q*, *Q*, or other unit meeting a given featural description, [F].

b. CORR-X:$:X — Assess a violation for every consecutive pair of X and X separated by no more and no less than one syllable boundary ($),where X is a *q*, *Q*, or other unit meeting a given featural description, [F].

c. CORR-X:∞:X (CORR-XX)[4] — Assess a violation for every consecutive pair of X and X at any distance that are not in a surface correspondence relationship, where X is a *q*, *Q*, or other unit meeting a given featural description, [F].

These correspondence relationships become unstable when corresponding units are sufficiently similar to trigger interaction but too uncomfortably similar to stably co-exist at a given distance, as determined by Correspondence Limiter (CORR-Limiter) constraints (Bennett 2013).[5] Examples include the following:

(4) a. IDENT-XX [F] — Assess a violation for every consecutive pair of corresponding elements that do not agree in [F]. (Two corresponding *Q*'s are considered identical if the strings of *q*'s comprising them are identical.)

b. XX-EDGE (**B**) — Assess a violation for every correspondence set that crosses boundary edge, **B**.

c. XX-(**U**)ADJ — Assess a violation for every correspondence set that is separated by a unit, **U** (for example, a syllable).

In this approach, harmony and dissimilation are optimizing repairs for unstable similarity- and proximity-driven surface correspondences, moderated by the ranking or weighting of CORR and CORR-Limiter constraints. (For discussion of the concept of instability in surface correspondence, see e.g., Wayment 2009; Inkelas and Shih 2014).

2.3 TONE AGREEMENT IN ABC+Q

In ABC+Q, *q* subsegments are the locus of tone features; narrowly defined, *q* is the tone-bearing unit (TBU). (For discussion of tone-bearing units, see §3.1.) The regulation of

[4] For shorthand, CORR constraints without any distance requirements are alternatively written as CORR-XX.
[5] In dealing with long distance consonant dissimilation, Bennett 2013 calls this class of constraints "CC Limiters." We generalize to any surface correspondence relationship.

tone patterns is effected by correspondence and tonal (dis)harmony among those *q* subsegments and *Q* segments that are sufficiently similar and proximal to interact, as specified by CORR. In this broader sense, the phonological unit to which tone reports is a correspondence set. What is treated as tone "spread" between TBUs in AP is treated in ABC as tonal agreement within a correspondence set. AP's "delinking" is, in ABC+Q, dissimilation in tone to avoid unstable correspondence. We illustrate the basic ABC+Q system here with two examples of tone agreement, *i.e.* the classic 'spreading' tone alternation that AP captures. The first example of tone agreement produces long spans of tonally identical *Q*s; the second is local, subsegmental tonal *q* agreement that results in contour tone formation.

Chilungu (Bantu, Zambia) demonstrates tone agreement over several segments, triggered by prefixal H tone and affecting following toneless roots (Bickmore 1996; as cited in Yip 2002:68):

(5)
	kú-vúl-à	'to be enough'
	kú-víímb-à	'to thatch'
	kú-fúlúmy-à	'to boil over'
	kú-sáákúl-à	'to comb'
	kú-sóóbólól-à	'to sort out'

Under an ABC approach, CORR-VV requires pairs of vowels to correspond, and IDENT-VV [tone] compels corresponding vowels to be tonally identical. IDENT-IO [H tone] preserves input H, resulting in assimilation which converts L (or toneless) vowels to H, rather than the reverse. Tone harmony that is bounded by the penult is a common pattern in Bantu verbs; a high-ranking markedness constraint against final H vowels (*FINAL-H) accounts for why H does not harmonize onto the final V. The winning candidate (6a) satisfies *FINAL-H and IDENT -IO [H] and does better than any of the losing candidates at satisfying CORR and IDENT.

(6)
		/kú-fulumy-a/	*FINAL H	ID-IO [H]	ID-VV [tone]	CORR-VV
☞	a.	kú$_1$-fú$_{1,2}$lú$_2$my-à	(0)	(0)	(0)	(1)
~	b.	kú-fùlùmy-à				**W** (1~3)
~	c.	kú$_1$-fù$_{1,2}$lù$_2$my-à			**W** (0~1)	(1~1)
~	d.	kù$_1$-fù$_{1,2}$lù$_2$my-à		**W** (0~1)		(1~1)
~	e.	kù$_1$-fù$_{1,2}$lù$_{2,3}$my-à$_3$		**W** (0~1)		**L** (0~1)
~	f.	kú$_1$-fú$_{1,2}$lú$_{2,3}$my-á$_3$	**W** (0~1)		**W** (0~1)	**L** (0~1)

(In this example, the targets of H tone assimilation are assumed to be toneless underlyingly; if they had been assumed to be L, the analysis would have been similar, but a low-ranked IDENT-IO [L tone] would have been violated.)

ABC+Q can also refer to the subsegmental *q* level for correspondence and agreement. In Yoruba (Niger-Congo, Nigeria), for example, partial assimilation of a L-toned vowel to a preceding H-toned vowel produces a HL contour (7a); similarly, a LH contour is formed from partial assimilation of a H-toned vowel to a preceding L-toned vowel (7b) (Pulleyblank 1986:110; Akinlabi and Liberman 2001).

(7)	a.	/ó-pọ̀/	→	[ópộ]		'it is plentiful'
		(cf. /kò-pọ̀/	→	[kòpọ̀]		'it is not plentiful')
		/rárà/	→	[rárâ]	'elegy'	
	b.	/àlá/	→	[àlǎ]	'dream'	

Viewed at the *Q* level, partial tone assimilation in Yoruba does not make consecutive segments more identical. This makes contour-creating tonal assimilation a challenge to standard ABC, which is segment-based. Neither a L vowel nor a vowel with HL following tone is tonally identical, at the segment level, to a preceding H-toned vowel. Q theory provides a solution via subsegmental correspondence, allowing the grammar to reference units below the segment level. In Yoruba, tone harmony results in tonal identity between two consecutive vowel subsegments across a syllable boundary, mandated by CORR-v:$:v (see (3b)). Excess tone assimilation is prevented by input-output faithfulness, which outranks general CORR-vv, as in (8d, e).

(8)

		/rárà/ = /r(á á á)r(à à à)/	CORR-v:$:v	ID-vv [tone]	ID-IO v[tone]	CORR-vv
☞	a.	rárâ r($á_1$ $á_{1,2}$ $á_{2,3}$)r($á_3$ $à_4$ $à_4$)	(0)	(0)	(1)	(1)
~	b.	rárà r(á á á)r(à à à)	**W** (0~1)		**L** (1~0)	**W** (1~5)
~	c.	rárà r(á á $á_1$)r($à_1$ à à)		**W** (0~1)	**L** (1~0)	**W** (1~4)
~	d.	rárá r($á_1$ $á_{1,2}$ $á_{2,3}$)r($á_{3,4}$ $á_{4,5}$ $á_{5,6}$)			**W** (1~3)	**L** (1~0)
~	e.	rárâ r($á_1$ $á_{1,2}$ $á_{2,3}$)r($á_{3,4}$ $à_{4,5}$ $à_{5,6}$)		**W** (0~1)	(1~1)	**L** (1~0)
~	f.	rárâ r(á á $á_1$)r($á_1$ à à)			(1~1)	**W** (1~4)

Yoruba has three tones in its inventory: H, M, L. An interesting wrinkle in Yoruba is that M-toned vowels do not undergo or trigger partial tonal assimilation; in *ōlè* 'thief' and *īlé* 'house', ML and MH sequences remain intact (Akinlabi and Liberman 2001). Previous AP approaches captured this asymmetry by underspecifying M tone (Pulleyblank 1986;

Akinlabi and Liberman 2001) or otherwise treating it as unmarked (Pulleyblank 2004). In ABC+Q it could be captured with a high-ranking constraint requiring M-toned subsegments to correspond and agree with other subsegments in the same syllable. The latter approach captures the fact that Yoruba has no contour tones involving M. The CORR constraints on M tones would have to outrank the CORR constraint in (8) that requires subsegments to agree in tone.

2.4 SUMMARY: ABC+Q FOR TONE

The many-to-one and one-to-many linkings AP posited between tone and timing units allowed AP to describe contour tones and 'spreading', or assimilation, in an easy, natural way. We have shown that contour tones and tone assimilation can also be straightforwardly captured in ABC+Q, without recourse to the special representational machinery of association lines and operations thereon which characterized AP. The 'many-to-one' behavior of tone is captured in ABC+Q via the availability of strings of subsegmental timing units, *q*: this representational simplicity not only predicts an upwards limit on apparent many-to-one association but also provides a unified way of modeling tone behavior both segment-internally and -externally. The one-to-many behavior of tone is captured in ABC using agreement over similarity- and proximity-based correspondence sets, which also provides a way of capturing dissimilation between tones, or what in AP was handled via delinking.

In the following sections, we turn to a broader variety of tone behavior. First we consider tone patterns that AP, though designed around tone, never captured well (§3). Then we return to cases of tone behavior at which AP excelled, and consider how ABC can handle these cases and, in some instances, produce more stringent and explanatory predictions than AP could (§4). Section 5 concludes with a brief overall discussion.

3 ABC+Q SOLVES PROBLEMS THAT PLAGUED AP

While AP made significant gains in the description and analysis of tonal phenomena, certain fundamental AP assumptions of representation raise problems in the analysis of tone that have not been solved in the decades since the introduction of AP. One basic problem that we covered above in (§2.1) is the limitation of contour tones to an apparent maximum of three. Another, discussed in (§3.1), is the issue of defining the tone-bearing unit (TBU) in the context of consonant-tone interaction. A third is the obstacle posed by geometric constraints on association lines to the analysis of contour tone assimilation, discussed in (§3.2).[6]

[6] Another representational problem that AP has encountered is the need to undo representational linkages that are posited for independent purposes, a process termed *tonal fission* (Cassimjee and Kisseberth 1992). The problem is similar in some ways to the diphthongization of long vowels, also problematic in AP, as discussed in Hayes 1990. We do not engage with fission phenomena here due to the fact that many such cases interact with morphophonological opacity and/or downstep, which are beyond the scope of the cur-

3.1 TBU IN CONSONANT-TONE INTERACTION

In the AP-era literature, 'tone-bearing unit' is variably defined as the phonological unit on which tone is phonetically realized, or the phonological unit which licenses tone, i.e. the unit to which tones 'report'; see e.g., Leben 1973b, Yip 2002:50–52 for discussion. In one or another of these context, a wide variety of possible tone-bearing units have been proposed: segments (e.g., Woo 1972; Schachter and Fromkin 1968; McCawley 1970; Leben 1973a, b), moras (e.g., Hyman 1984, 1985), syllables or syllable rimes (e.g., Wang 1967; Chao 1968; McCawley 1970; Bao 1990), and even prosodic units as large as the word or phrase; see e.g., Pierrehumbert and Beckman 1988). Common operating assumptions are that TBU have to be (or contain) elements sufficiently sonorous to phonetically realize pitch (e.g., Gordon 2001; though cf. Dutcher and Paster 2008), and that units on which tone is never contrastive in the language are not eligible TBUs. As Yip (2002) points out, this can lead to somewhat circular definitions of relevant tonal units (Yip 2002:73ff). But the general consensus is that elements on which tone is never contrastive, such as onsets or obstruent codas, are not expected to be TBUs.

One of the greatest challenges for the definition of a TBU arises in consonant and tone interactions, in which consonants which are not traditionally assumed to be tone-bearing nonetheless affect tonal processes. Consonant-tone interaction typically comes in the form of depressor or elevator consonants, which affect tone in a number of ways, including low tone insertion, the blocking of low tone docking, downstep insertion, the blocking of high tone docking, the blocking of high tone shift, tone-induced segmental voicing changes, and the restriction of tone inventories. Depressor consonants are usually voiced obstruents or aspirated, fricated, or breathy voiceless obstruents, and elevator consonants are usually plain, voiceless obstruents (for overviews, see e.g., Bradshaw 1999; Lee 2008; Tang 2008; Moreton 2010; a.o.). For example, in Ikalanga (Bantu, Botswana), a typical depressor consonant effect prevents H tone agreement between prefix and stem (9a) when a voiced obstruent intervenes (9b) (data from Mathangwane 1999).[7]

(9)		Underlying	Surface		
	a.	/né-tʃì-wìlò/	nétʃíwílò		'by chance'
		/né-tʃì-lòpà/	nétʃílópà		'and a liver'
	b.	/né-bánì/	nébànì	*nébánì	'and a forest'
		/né-ʒání/	néʒànì	*néʒánì	'and a leaf'

Insofar as AP *a priori* restricts tonal operations to TBUs, any evidence that non-TBUs interfere with tone processes creates a serious problem. Solutions put forth in the AP tra-

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rent work. We do note, however, that fission as a concept is conceptually unproblematic in ABC+Q; it is simply local dissimilation.

[7] A running theme in the literature on tone is whether, in a language contrasting H and L tone, L should be underspecified or present throughout the derivation (see, e.g., Pulleyblank 1986; Myers 1998; Hyman 2001). We avoid this issue here and treat tone as fully specified throughout for consistency across our examples. However, ABC+Q is fully compatible with varying degrees of underspecification in inputs and even outputs.

dition have relaxed the fundamental tone-to-TBU assumption in AP, allowed tone to exceptionally interact with certain segments, and/or posited the interaction of tone and segmental features beyond TBUs, such as [stiff], [slack], etc. (e.g., Halle and Stevens 1971; Bradshaw 1999; Downing and Gick 2001; Lee 2008; Tang 2008; Chen and Downing 2011; van Oostendorp, forthcoming). However, such modifications weaken the foundational building blocks of AP, in which TBUs are the elements to which the Association Conventions map tones (see §4.4).

In ABC+Q, the TBU per se, narrowly defined, is the *q* subsegment. The operating null hypothesis is that tone is a featural property of every subsegment. (Whether tone is contrastive on a given unit is a property of the grammar.) Thus ABC+Q naturally allows onsets, as in Ikalanga, to interact with tone when featural co-occurrence constraints permit and when the correspondence and identity-driven grammar demands (i.e., when similarity and proximity conditions are met). For the Ikalanga example introduced above, then, the depressor consonant effect is a result of the markedness-driven blocking of correspondence and ensuing tonal identity. Illustrated in the tableau in (10), modeling the form in (9b), CORR-X::X and CORR-[X::X]s require adjacent segments and adjacent tautosyllabic segments, respectively, to correspond and (via IDENT-XX) [tone]) to agree in tone. A high-ranked markedness constraint (*H/[+cons, +voice]) prevents a voiced intervocalic obstruent from agreeing tonally with adjacent H vowels. The optimal output, (10a), has maximal correspondence and tone agreement while taking into account the limitations imposed by the high-ranking featural co-occurrence constraint.

(10)

		/…é-b̀á…/	*H/[+cons, +voice]	IDENT-XX [tone]	CORR-X::X	CORR-[X::X]$_\sigma$	IDENT-IO V[tone]
☞	a.	é$_1$b̀$_2$à$_2$	(0)	(0)	(1)	(0)	(1)
~	b.	é$_1$b́$_{1,2}$á$_2$	**W** (0~1)		**L** (1~0)		**L** (1~0)
~	c.	éb̀á			**W** (1~2)	**W** (0~1)	**L** (1~0)
~	d.	é$_1$b̀$_{1,2}$á$_2$		**W** (0~2)	**L** (1~0)		**L** (1~0)
~	e.	è$_1$b̀$_{1,2}$à$_2$					**W** (1~2)

Feature co-occurrence constraints for depressor and elevator consonants (e.g., *H/[+cons, +voice] and *L/[+cons, -voice], respectively) are part of a family of phonetically-grounded segmental markedness constraints based on articulatory incompatibility or affinity of certain feature values and tone (Tang 2008; following Peng 1992; Archangeli and Pulleyblank 1994). Because tone is potentially in the description of every minimal subsegment *q*, the existence of markedness restrictions on co-occurring tone and segmental features is expected in ABC+Q. Comparatively, the existence of such markedness restrictions is conceptually dissonant with the AP assumption that the TBU, however defined, mediates between tone features and segmental features, which don't directly interact.

ABC+Q also allows for the possibility that consonants and tones can interact beyond the traditional depressor and elevator effects: for instance, consonants which meet correspondence-imposed requirements of similarity and proximity can facilitate tonal interaction between flanking, more traditional TBUs. Shih 2013 points to an example in Dioula d'Odienné (Mande, Côte d'Ivoire), in which onsets that are more similar to their surrounding vowels in sonority and nasality allow regressive H tone harmony between the vowels (e.g., /tùrú / → [túrú] 'oil, def.'), while onsets that are less similar do not (e.g., /hàmì/ → [hàmí] 'concern, def.'). Another example of facilitatory tone spread by a consonant is a case in Nupe (Niger-Congo, Niger-State) in which a vowel partially assimilates in tone to a preceding vowel only if a voiced sonorant or obstruent intervenes (e.g., [èlě] 'past', [èdǔ] 'taxes') (data from George 1970). If the intervening consonant is voiceless, no tone spread occurs (e.g., [ètú] 'parasite'). In sum, tone harmony facilitation by intervening consonants is predicted under ABC+Q, in which tone is a potential feature of all (sub)segments, and interaction between consonants and tone is governed by similarity- and proximity-mandated correspondence (e.g., CORR-q::q), which can result in agreement (e.g., IDENT-qq)—i.e., harmony facilitated by consonants and vowels.

3.2 CONTOUR TONES

A foundational insight of AP is the decomposition of rises and falls into sequences of level tones on a single TBU: LH for rise, and HL for fall, (11).

(11)

Rise	Fall
CV	CV
/\	/\
L H	H L

The level tone approach to contour tones has afforded phonologists significant traction in analyzing derived contours (i.e., those that arise from assimilation, as in Yoruba (7), and tone melodies which manifest as contour tones on words with just one TBU but as sequences of level tones on longer words (see discussion in §4.4).[8]

AP's decomposition of contour tones into a sequence of level tones linked to a single TBU, however, is not without problems (see Yip 2002:50–52 for extensive discussion): it has difficulty with cases in which contours behave like single units in harmony

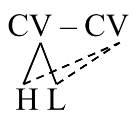
[8] The approach also readily captures the common cross-linguistic restriction of complex tone melodies (i.e., HL, LH) to bimoraic syllables (i.e., CVV, CVC); this pattern follows if each mora can license only one level tone. In such a case, only a bimoraic syllable could host a tonal contour. In such a case, however, the AP literature has disagreed as to whether the mora or the syllable is the TBU. See e.g., Hyman 1985 vs. Leben 1985 on Hausa. See also Gussenhoven and Teeuw 2007 for the proposal that both the mora *and* the syllable are TBUs in Yucatec Maya.

and in dissimilation. (For more extensive discussion of partial and whole contour (dis)harmony, including segmental phenomena, see Inkelas and Shih 2013a; Shih and Inkelas 2014.) Example (12) illustrates the well-known pattern of contour tone assimilation in Changzhi (Chinese dialect in Shangxi): the entire tonal complex of the root is duplicated on the diminutive suffix [-tə^{ʔ}] (Yip 1989; Bao 1990; data from Duanmu 1994):

(12)	a.	/kuə$_{213}$-tə$^{ʔ}_{535}$/	→	[kuə$_{213}$-tə$^{ʔ}_{213}$]	‘pan-DIM’
	b.	/səŋ$_{24}$-tə$^{ʔ}_{535}$/	→	[səŋ$_{24}$-tə$^{ʔ}_{24}$]	‘rope-DIM’
	c.	/ti$_{535}$-tə$^{ʔ}_{535}$/	→	[ti$_{535}$- tə$^{ʔ}_{535}$]	‘bottom-DIM’
	d.	/k^{h}u$_{44}$-tə$^{ʔ}_{535}$/	→	[k^{h}u$_{44}$- tə$^{ʔ}_{44}$]	‘pants-DIM’
	e.	/təu$_{53}$-tə$^{ʔ}_{535}$/	→	[təu$_{53}$-tə$^{ʔ}_{53}$]	‘bean-DIM’

Assimilation of the entire contour tone complex via spreading in traditional AP would result in illicit line crossing, as shown in (13). Line-crossing has been argued to be an inviolable constraint for AP (e.g., Zoll 2003:241; though cf. Coleman and Local 1991).

(13)



To resolve this problem, some researchers in AP have appealed to feature-geometry tone class nodes —i.e., sequences of tones attached to class nodes that can spread (Yip 1989; Bao 1990; see also e.g., Inkelas 1987; Yip 1992; Hyman 1993 and the tonal complexes of Akinlabi and Liberman 2001, 2006). Duanmu (1994) takes a different approach, positing a distinction in AP between tone spreading and tone copying, i.e. the phonologically motivated reduplication of a tone contour).[9] Level tones assimilation takes place by spreading, according to Duanmu, but contour tones copy.

In ABC+Q, with its *q* and *Q* levels of representation, the debate over whether a contour tone is a sequence of tones (e.g., HL), or an internally complex tonal constituent is a moot point. When correspondence is stated over segments *Q* (e.g., CORR-QQ » IDENT-IO [tone]), whole contours can correspond and interact, resulting in patterns such as Changzhi’s contour harmony, as illustrated in (14). When correspondence is stated over subsegments *q* (e.g., CORR-qq), independent behavior of the tonal components of a contour results: for example, assimilation of adjacent subsegments rather than whole segments, as was demonstrated by Yoruba contour creation (8). (For reasons of space, the following tableau illustrates only two, rather than the maximal three, internal subsegments.)

[9] Note that feature duplication to achieve assimilation was also posited, e.g. by Archangeli and Pulleyblank 1994, to achieve vowel harmony across a transparent vowel without creating a gapped autosegmental structure. The need for this move is eliminated in the ABC approach to harmony, in which strict adjacency is not required for assimilation or other interactions to take place.

(14)

		/â…á/ = (á à)…(á á)	CORR-VV	IDENT-XX [tone]	IDENT-IO v[tone]	CORR-vv
☞	a.	(á à)$_1$…(á à)$_1$	(0)	(0)	(2)	(3)
~	b.	(á à)$_1$…(á á)$_1$		**W** (0~1)	**L** (2~0)	(3~3)
~	c.	(á à$_1$)…(à$_1$ á)	**W** (0~1)		**L** (2~1)	**L** (3~2)

Duanmu's distinction between the mechanisms of spreading versus copying becomes unnecessary in ABC+Q: all phonological assimilation is handled through correspondence.

Dissimilation of contour tones is another area in which traditional AP struggles but ABC+Q operates with ease. For example, in Tianjin, tonal dissimilation is obligatory when adjacent syllables would otherwise exhibit identical tonal profiles, whether level (15a) or contour (15b) (Chen 1985; Yip 1989:163; Yip 2002:51, 179):

(15)	a.	L.L	→	LH.L		/fei$_{L}$/	→	[fei$_{LH}$.ji$_{L}$]	'airplane'
	b.	HL.HL	→	L.HL	*LH.HL	/jing$_{HL}$/	→	[jing$_{L}$.zhong$_{HL}$]	'net weight'
		LH.LH	→	H.LH	*HL.LH	/xi$_{LH}$/	→	[xi$_{H}$.lian$_{LH}$]	'wash one's face'

In AP, dissimilation is handled by the Obligatory Contour Principle (OCP), which prohibits adjacent identical tones (e.g., *H H). For tonal contours in Tianjin, however, the immediately adjacent tonal autosegments are not the same (L**H.L**H, H**L.H**L)) and would therefore not trigger the OCP: only compared at the whole contour level can contours be identified as identical (**LH**.**LH**). As in the above discussion of contour tone assimilation, the problem AP has with contour tone dissimilation is that tone contours are sequences, not constituents, in AP. No such issue arises for ABC+Q, in which tone dissimilation arises from the same surface correspondence relationship mandates (CORR-QQ, CORR-qq) that are used to model contour and level tone assimilation. Bennett (2013) has shown that dissimilation results in ABC when a constraint against correspondence across a boundary (here, a morpheme boundary) co-exists with a limiter constraint (as in (4)), compelling phonologically similar elements to correspond. When similar elements are separated by a morphological boundary, dissimilation can be the optimal repair. In Tianjin, dissimilation occurs when vowels in adjacent syllables would be tonally identical across a morpheme boundary. With its richer representations, ABC+Q can reduce contour and level assimilation and dissimilation to the same basic mechanism, making it simultaneously more descriptively adequate and more parsimonious than AP.

4 KEY TONAL OPERATIONS

In this section we turn to basic tonal processes beyond the simple correspondence and identity behavior discussed above. These include: tone plateauing (§4.1), tone absorption (§4.2), across-the-board tone changes (§4.3), and lexical tone melodies (§4.4). Any adequate theory of tone must account for these patterns.

4.1 Plateauing

'Plateauing' is a kind of tone assimilation that is special in having a two-sided environment. It typically targets low-toned vowels sandwiched between vowels with higher tones. In Luganda (Bantu, Uganda), L vowels occurring between two lexically H-toned morphemes in the same word will assimilate to H tone (16a vs. b) (Hyman and Katamba 1993):

(16)	a.	bá-mù-láb-à	→	bá-mú-láb-à	'they see him'
	b.	bá-tù-sìb-à	→	bá-tù-sìb-à	'they tie us'
		à-tù-láb-à	→	à-tù-láb-à	'he sees us'

Plateauing can be achieved in a number of ways via ABC. The preference for H plateaus over troughs (i.e., HLH) emerges from the interaction between Corr-HH, a constraint requiring H-toned elements to correspond, and XX-σ Adj, the restriction that corresponding segments must be in adjacent syllables (see definition in §2.2:(4c) and Inkelas and Shih, forthcoming for more discussion). This interaction is illustrated in (17).

(17)

		/á…à…á/	Corr-HH	XX-σ Adj	Id-IO (H)
☞	a.	á$_1$…á$_{1,2}$…á$_2$	(0)	(0)	(0)
~	b.	á$_1$…à…á$_1$		**W** (0~1)	
~	c.	á$_1$…à$_{1,2}$…á$_2$	**W** (0~1)	**W** (0~1)	
~	d.	à$_1$…à$_{1,2}$…à$_2$			**W** (0~2)
~	e.	á…à…á	**W** (0~1)	**W** (0~1)	
~	f.	á…à$_1$…à$_1$			**W** (0~1)

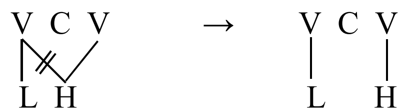
The advantage of the ABC approach over AP for tone plateauing is that it is not necessary to decide whether plateauing is rightward spread, leftward spread, or yet a third kind of operation. In ABC, correspondence across intervening L vowels compels them to assimilate to the two-sided H environment. On two-sided environment effects in general, see Lionnet 2014.

4.2 Tone absorption

One of the classic tone operations discussed by Hyman and Schuh (1974), "tone absorption" refers the simplification of a tonal contour on one TBU (usually syllable) when one of the elements of the contour is tonally identical to the closest portion of a neighboring

TBU (syllable), as illustrated in (18a) with an example from Mbui Bamileke (Niger-Congo, Cameroon) (Hyman and Schuh 1974:95). In AP, absorption corresponds to a de-linking rule applying to the middle association line in a 'zigzag' configuration, as shown in (18b) for the simplification of a LH contour preceding a H tone.

(18) a. /lɔ̌ː + sə́ŋ/ → [lɔ̀ː sə́ŋ] 'look for the bird'

b. 

c. LH.HH → LL.HH

Illustrated schematically in (18c), the effects of tone absorption in ABC instead follow from the combined efforts of two requirements: (1) a requirement that tautosyllabic sub-segments agree in tone (i.e., CORR-[v::v]$_{\sigma}$, which bans contours generally) *and* (2) a requirement that tone features change at syllable boundaries. The latter, needed independently to characterize tone melody languages (see section 4.4), can be accomplished by requiring tonally identical units to correspond and by banning correspondence across syllable boundaries (CORR-T:$:T and qq-EDGE-σ). By themselves, neither CORR-[v::v]$_{\sigma}$ nor CORR-T:$:T can overcome input-output faithfulness. Contours do exist in Mbui Bamileke; so do sequences of tonally identical syllables. Taken together, however, the need to satisfy all three constraints can overcome input-output tone faithfulness and result in tone absorption. This ganging-up effect of CORR-[v::v]$_{\sigma}$ and CORR-T:$:T can be modeled using either additive constraint weights in Harmonic Grammar (HG) (e.g., Legendre et al. 1990, 2006; Farris-Trimble 2008; Potts et al. 2010; Pater 2015) or local conjunction of the constraints (e.g., Smolensky 1993, 2006; Baković 2000; Ito and Mester 2003; cf. Crowhurst and Hewitt 1997); below, we implement an HG approach.[10] As seen in the juxtaposition of tableaux (19) and (20), tone absorption only occurs when a *q* in a tonally contoured *Q* is followed by a tonally identical *q* in the next syllable. Thus, a LH contour followed by L in (19) does not level to become L.H or H.L; the optimal candidate (19a) is one in which highly weighted input-output faithfulness is satisfied (versus b, c). In comparison in (20), a LH contour followed by H "absorbs" to L.H; in this case, the otherwise fully faithful candidate (20b) is overcome by combined violations of both CORR constraints, resulting in a winning candidate (20a) that violates input-output faithfulness but maximally satisfies all of the correspondence conditions. The remaining candidates in (20) are given for completeness.

[10] Constraints were hand-weighted.

(19) No tone absorption

		/ăbà/ = (à á)b(à à)	ID-qq [tone]	ID-IO v[tone]	CORR-[v::v]$_\sigma$	CORR-T:\$:T	qq-EDGE-σ	
		weights	*20*	*10*	*6*	*6*	*6*	$\mathcal{H}$
☞	a.	(à á)b(à$_2$ à$_2$)			**L** (-1~0)			*-6*
~	b.	(á$_1$ á$_1$)b(à$_2$ à$_2$)		**W** (0~-1)				*-10*
~	c.	(à$_1$ à$_1$)b(á$_2$ á$_2$)		**W** (0~-3)				*-30*

(20) Tone absorption

		/ăbá/ = (à á)b(á á)	ID-qq [tone]	ID-IO v[tone]	CORR-[v::v]$_\sigma$	CORR-T:\$:T	qq-EDGE-σ	
		weights	*20*	*10*	*6*	*6*	*6*	$\mathcal{H}$
☞	a.	(à$_1$ à$_1$)b(á$_2$ á$_2$)		**L** (-1~0)				*-10*
~	b.	(à á)b(á$_2$ á$_2$)			**W** (0~-1)	**W** (0~-1)		*-12*
~	c.	(à á$_1$)b(á$_{1,2}$ á$_2$)			**W** (0~-1)		**W** (0~-1)	*-12*
~	d.	(à$_1$ á$_1$)b(á$_2$ á$_2$)	**W** (0~-1)			**W** (0~-1)		*-26*
~	e.	(á$_1$ à$_1$)b(á$_2$ á$_2$)	**W** (0~-1)	**W** (-1~-2)				*-46*
~	f.	(à$_1$ à$_{1,2}$)b(á$_{2,3}$ á$_3$)	**W** (0~-1)	(-1~-1)			**W** (0~-1)	*-26*
~	g.	(á$_1$ á$_{1,2}$)b(á$_{2,3}$ á$_3$)		(-1~-1)			**W** (0~-1)	*-16*
~	h.	(á$_1$ á$_1$)b(á$_2$ á$_2$)		(-1~-1)		**W** (0~-1)		*-16*
~	i.	(à á)b(à á)		(-1~-1)	**W** (0~-2)			*-22*
~	j.	(à á)b(à$_1$ à$_1$)		**W** (-1~-2)	**W** (0~-1)			*-16*

Modeled in this way, the optimal distribution of two contrasting tone feature values over a two-TBU domain aligns with TBU boundaries, a robust pattern that is also found in lexical tone melody distributions (see §4.4).

4.3 ACROSS-THE-BOARD TONE CHANGES

A hallmark achievement of AP is the ability of its many-to-one mapping representations to capture effects in which a single autosegment undergoes featural changes that affect every skeletal position to which the autosegment is linked. An example from 'Meeussen's Rule' in Shona (Bantu, Zimbabwe) is illustrated below (Odden 1986). Meeussen's Rule lowers a H-toned vowel to L immediately following a H-toned vowel in a preceding morpheme. As seen, it applies in one fell swoop to a sequence of H-toned vowels.

(21)	a.	/né-hóvé/	→	[né-**hòvè**]	'with a fish'
	b.	/né-mbúndúdzí/	→	[né-**mbùndù**dzì]	'with worms'
	c.	/né-bénzíbvùnzá/	→	[né-**bènzì**bvùnzá]	'with an inquisitive fool'

In the AP era, this across-the-board effect is attributed to representations: a single mulitply linked H becomes a single multiply linked L. (AP does face a challenge in explaining why, when the H autosegment is deleted, its replacement (a L autosegment) retains the original linkages of the deleted H; to work, the AP analysis has to assume that H is transformed into L, rather than deleting and being replaced by L in classic autosegmental manner.)

In ABC, across-the-board effects are attributed to correspondence: a sequence of stem-internal H-toned TBUs must correspond. If, due to the dissimilatory Meussen's rule, the stem-initial TBU is required to dissimilate from H to L, so must the other elements in its correspondence chain, illustrated in simplified terms in (22). Here, XX-EDGE (Stem) is the limiter constraint (see (4)) prohibiting correspondence across a stem boundary; CORR-[H:$:H] and CORR-[VV] require correspondence between consecutive high-toned vowels and consecutive vowels, respectively. Since XX-EDGE(Stem) is ranked higher, dissimilation is the outcome. CORR-[VV]$_{stem}$ causes H→L dissimilation at the prefix-stem boundary to propagate to other stem vowels.

(22)

		/á - á…á/	XX-EDGE (STEM)	ID-XX [tone]	CORR-H:$:H	CORR-[VV]$_{stem}$	CORR-VV
☞	a.	á - à$_1$…à$_1$	(0)	(0)	(0)	(0)	(1)
~	b.	á$_1$ - á$_{1,2}$…á$_2$	**W** (0~1)				**L** (1~0)
~	c.	á - á$_1$ …á$_1$			**W** (0~1)		(1~1)
~	d.	á - à…á				**W** (0~1)	**W** (1~2)
~	e.	á - à$_1$…á$_1$		**W** (0~1)			(1~1)

A challenge this data poses for ABC is that the surface stem correspondence is potentially opaque, motivated by tonal similarity in the input. In (21c), the stem-initial string of two adjacent input H vowels both lower to L, but the stem-final input H-toned vowel does not. This suggests that input-based (‘old’) similarity and correspondence relationships may act differently from output-based (‘new’) ones, in the manner of the old vs. new markedness constraints of McCarthy 2003. The role of input-based correspondence is a fascinating one, further explored in Inkelas & Shih (in progress).

4.4 LEXICAL TONE MELODIES

One of the most striking results from the AP tone literature is the analysis of tone distribution in so-called ‘tone melody’ systems, in which the grammar appears to license a small set of possible tone melodies whose surface realization is predictable from the number of TBUs in the domain. Arguably the most famous case of this kind is Mende, as analyzed in Leben 1973ab, 1978 (see also Hyman 1987 on Kukuya). On Leben’s original analysis, Mende has an *a priori* inventory of 5 tone melodies: H, L, HL, LH, and LHL. Leben argued that the distribution of tone melodies over words of differing syllable length is predictable from universal one-to-one, left-to-right autosegmental association conventions (see also Goldsmith 1976). Words with more tones than syllables are predicted to exhibit contours on the right edge (23a, b). Words with more syllables than tones are predicted to exhibit level spans on the right edge, due to the default spreading rule (23c, d). Words with as many syllables as tone should exhibit perfect one-to-one matches, as in (23e, f).

(23) a. nya.ha ‘woman’ b. mbu ‘owl’
L H L H L

c. nda.vu.la ‘sling’ d. bɛ.lɛ ‘pants’
L H L

e. ni.ki.li ‘peanut’ f. ngi.la ‘dog’
L H L H L

Leben’s AP analysis relies crucially on the Obligatory Contour Principle, banning adjacent identical autosegments to restrict the existence of melodies such as HHL and LLH in the input to the association conventions (versus HL and LH, which should surface on trisyllabic words as HLL and LHH, respectively). The success of the Mende analysis has been widely touted as a success story for autosegmental representations and the OCP.

However, exceptions in Mende to the universal autosegmental mapping procedures have been noted, with surface tone melody patterns present in the language beyond the five on which Leben focused (Dwyer 1978; Conteh et al. 1983; Inkelas and Shih, forthcoming). A statistical analysis by Inkelas and Shih (forthcoming) of 2,747 nouns in

Innes's (1969) Mende lexicon supports these objections. For example, of 851 trisyllabic nouns in the lexicon, Leben's 5-melody inventory accounts for only 80% of the data. The remaining 20% of trisyllabic nouns present with surface HLH, LHLH, or LHLHL melodies (e.g., *ndálòmá* 'significance'; *nyɛ̀kɔ́lìí* 'iron rod currency'; *sǔgònɛ̂* (type of bird).

When the autosegmental Association Conventions are tested by examining the distribution of melodic tones over syllables, accuracy in describing the attested surface tone patterns dips to 55%. As illustrated below, there are multiple ways to map each "abstract" tone melody over three syllables. The boldfaced melodies are the ones predicted by the 1-1, left-to-right Association Conventions. In the case of both HL and LH melodies, the alignment these conventions predict is not the most commonly attested surface tone pattern.

(24) Trisyllabic surface tone patterns in Mende nouns

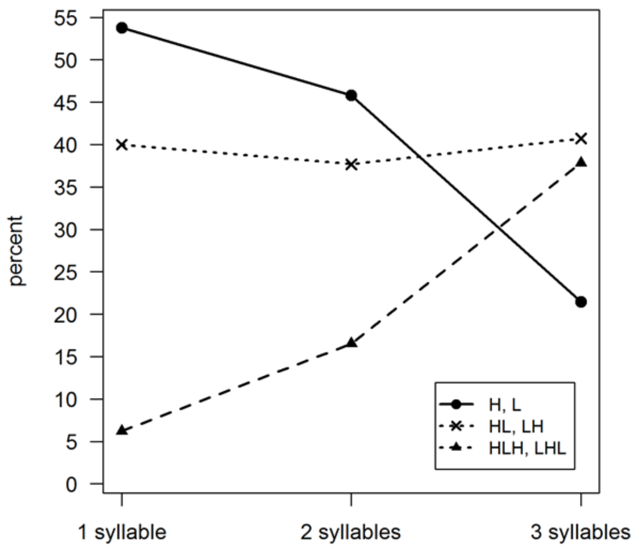
<H>	**H.H.H**	**101**	<L>	**L.L.L**	**25**
<HL>	H.H.L	58	<LH>	L.L.H	63
	H.L.L	**38**		**L.H.H**	**40**
	H.H.HL	25		LH.H.H	6
	HL.L.L	5		L.L.LH	3
	H.HL.L	1			
<HLH>	**H.L.H**	**21**	<LHL>	**L.H.L**	**142**
	H.L.LH	1		L.L.HL	31
				LH.L.L	17
				LH.H.L	4
				LH.H.HL	4
				L.H.HL	4
				L.HL.L	2

Recognizing that LH melodies more commonly map to trisyllabic words as LLH than as LHH, Leben 1973a actually modified the association conventions to operate from right to left with the LH melody. Even with this modification, many surface forms still fall outside the range of predicted patterns.

A fresh look at the lexical data for Mende reveals two broad tendencies: [1] for contours in polysyllabic nouns to be final (291 of 695 nouns (i.e., 42%) with contour tones exhibit contours in nonfinal position), and [2] for melody complexity to correlate with word length. The first observation is one also made by previous researchers: Zoll 2003, for example, proposes an alignment constraint restricting contours to final position in a constraint-based account of Mende tone alignment based over autosegmental representations. Zoll's contour alignment constraint was ahead of its time in an era that relied on autosegmental representations for tone, inasmuch as contours are not representational constituents in AP (see §3.2). Imported into an ABC+Q analysis, however, Zoll's insight is easily modeled via CORR-q::q, restricted to *q*'s in nonfinal syllables. The constraint CORR-$[\mathrm{q::q}]_{\sigma_w}$ compels subsegments within nonfinal syllables to correspond (and, via IDENT-XX[tone]), agree tonally.

The second observation is more novel: as seen in (25), 3-tone melodies (e.g., LHL and HLH) constitute a larger percentage of trisyllabic word surface tone patterns than they do of shorter words. Likewise, 1-tone melodies (e.g., H and L) are more frequent in mono- and disyllabic words than in trisyllabic words.

(25) Mende melody percentages by number of syllable in nouns



The leading idea of the AP analysis of melodies is that melodies exist entirely independently of the words they map to and should, therefore, be unrestricted by properties such as word length.. A more nuanced possibility is offered in an ABC+Q account that is couched in maximizing similarity in highly proximal subsegments (i.e., *q*'s within syllables) and dissimilarity across boundaries (i.e., *q*'s across syllables). Such an account correctly predicts that tonal transitions should coincide maximally with syllable boundaries, thus leading to a correlation between word length and surface tone complexity. This prediction of ABC+Q illustrated in (26), for trisyllabic nouns. The optimal, most frequent melody for a 3-syllable word is L.H.L, which features no contour tones (thus exhibits Q-internal *q* agreement) and has tone transitions at each syllable boundary (disagreement across *q*'s at syllable edges). Suboptimal, less frequently-attested tonal surface patterns are ones that have level (i.e., agreeing) tones across syllable boundaries (26b, c) or contour tones (26d, e). The column headed *'freq'* lists the number of trisyllabic nouns in Innes 1969 that manifest the pattern in question. The more optimal in terms of constraint satisfaction, the more frequent the pattern is (correctly) predicted to be:[11]

[11] For simplicity, other possible surface tone patterns for trisyllabic words are excluded from the tableau. For example, H.L.H violates qq-SYLL ADJ (see §4.1) and is thus suboptimal. We also omit candidates which satisfy CORR but violate IDENT-XX[tone].

(26)

		Q Q Q = qq.qq.qq	*freq*	qq-EDGE σ	CORR-[q::q]$_{\sigma_w}$	CORR-qq
☞	a.	L.H.L ($l_1l_1.h_2h_2.l_3l_3$)	142	(0)	(0)	(2)
~	b.	L.L.H ($l_1l_{1,2}.l_{2,3}l_3.h_4h_4$)	63	**W** (0~1)		**L** (2~1)
~	c.	L.H.H ($l_1l_1.h_2h_{2,3}.h_{3,4}h_4$)	40	**W** (0~1)		**L** (2~1)
~	d.	L.L.L ($l_1l_{1,2}.l_{2,3}l_{3,4}.l_{4,5}l_5$)	25	**W** (0~2)		**L** (2~0)
~	e.	L.L.$\widehat{\text{HL}}$ ($l_1l_{1,2}.l_{2,3}l_3.h_4l$)	31		**W** (0~1)	(2~2)
~	f.	$\widehat{\text{LH}}$.L.H ($l_1h_2.l_3l_3.h_4h_4$)	12		**W** (0~1)	**W** (2~3)

These findings suggest that what drives surface tone melody distribution in Mende is not the coupling of a pre-specified, OCP-approved inventory of melodies with a set of inviolable mapping procedures, but rather correspondence constraints which capture a different set of insights than those which drove the original AP approach to tone. The tendency in Mende for tone to agree within a (nonfinal) syllable is a matter of syllable-internal subsegmental (*qq*) correspondence; the tendency for tone to change at syllable boundaries is a matter of correspondence failing across syllable edges, an effect modeled in ABC by Bennett in his approach to dissimilation.[12]

This correspondence-based approach to tone distribution in the lexicon is neutral with respect to the actual representation of tone: it requires neither an underlying inventory of independent lexical tone melodies nor the OCP.

This is not to say that tone melodies, or floating tones in general, are not needed in the theory, for other cases such as grammatical tone. However, we posit that a constraint- and correspondence-based approach has the potential to unite both lexical and surface patterns (i.e., morpheme structure constraints and phonological alternations) under a single analysis.

5 DISCUSSION & CONCLUSION

Largely driven by observations from the tonal domain, Autosegmental Phonology has long been a dominant theoretical powerhouse in describing both suprasegmental and segmental phonological patterns alike. In this paper, we have engaged tonal phenomena with an eye towards how a surface optimizing theory with minimal representational architecture—i.e., a type of approach that has been championed in the past two decades of modern phonological theory—would deal with such behavior. We have argued that

[12] Paradigmatic constraints also play a role, favoring maximally diverse tone melodies across the language.

Agreement-by-Correspondence coupled with Q Theory better predicts the range of tonal behaviors observed in language. This move once again unites parallel suprasegmental and segmental phonology under a single theoretical mechanism of optimization over correspondence relationships (including input-output correspondence, base-reduplicant correspondence (McCarthy and Prince 1995), and output-output correspondences within a paradigm (e.g., Benua 1997).

In her textbook on tone, Yip (2002:84ff) summarizes five primary behaviors of tone that a phonological theory must be prepared to account for, paraphrased in (27):

(27)	Mobility	manifestation of surface tone away from its underlying location
	One-to-many	level tone span over two or more timing units
	Many-to-one	more than one tone on a single *Q* unit or larger
	Tonelessness	timing units that never acquire phonological tone
	Stability	survival of tone after loss of an original host segment

Whereas these tonal behaviors are nearly entirely representationally-instantiated in AP via autosegmental linking and operations over linkages, we have shown here that ABC+Q capitalizes on the grammar itself to account for the crucial tone behaviors. In general under ABC+Q, the mobility of tones (and other features) arises from similarity- and proximity-driven agreement and disagreement principles of surface correspondence, versus the linking and delinking operations of AP. What Yip refers to autosegmentally as the behavior of "one-to-many" is also captured in ABC+Q by the grammar, via harmonizing pairwise correspondence spans. And "many-to-one" behavior is captured by the grammar because, with Q theory, ABC can now reference quantized subsegmental units (*q*). Unlike with AP, ABC+Q actually pushes the original autosegmental insight—that contour tones are sequences of level tones—to its logical limit: in ABC+Q, so-called "many-to-one" contours are no longer multiplicitous TBUs but instead are singular TBUs (i.e., *q*'s) sequenced in time.

In terms of tonelessness (e.g., vowels which lack their own contrastive tonal specifications on the surface), ABC+Q and AP are the same. In both theories, tonelessness is simply the absence of a given tone feature.

Tone stability, one major phenomenon identified by Yip that we have not addressed directly in this paper, should follow from vanilla input-output faithfulness with which an optimizing grammar is already endowed, namely IO faithfulness to tone features within the phonological feature bundle of an input unit. It should not be necessary to have IO faithfulness to geometric association "line" in AP (e.g., MAX/DEP-ASSOC). The phenomenon of tone stability is inextricably linked in the AP literature to the postulation of floating tones, which serve a highly diverse set of purposes in the AP literature, beyond the bounds of what this paper can cover. For example, floating tones have been posited in the analysis of downstep (for which register tone is an alternative; see e.g., Inkelas 1987; Snider 1990; Inkelas and Leben 1990; Hyman 1993), in the analysis of lexical tone melodies (see §4.4), and in the analysis of grammatical tone (for overviews, see e.g., McPherson 2014; Odden and Bickmore 2014; Hyman, to appear). The need for floating tones may ultimately hinge on how morphologically conditioned phonological patterns are implemented in general, an issue which is orthogonal to the ABC versus AP debate (for recent discussion of this issue for grammatical tone, see e.g., Jenks and Rose 2011:fn 18; McPherson 2014; on the issue more generally, see e.g., Kurisu 2001; Akinlabi 2011; Inkelas, to appear).

The crucial difference between ABC+Q and AP, then, is that ABC+Q assumes no association lines. We have illustrated herein that the grammar does not require representational association lines in order to account for the primary behaviors of tone.

One of the major advantages that we see of approaching tonal behavior with ABC+Q is that it once again brings together insights from both the segmental and tonal domains in the development of phonological theory. To nearly every typical tone behavior that we have surveyed in this paper, there are segmental analogues (cf. Hyman 2011, 2012). For example, Inkelas and Shih (2013b) point out numerous typological similarities between how contour tones, contour segments, and other string-to-string correspondences (e.g., Aggressive Reduplication; Zuraw 2002) behave in harmony and dissimilation systems. Reinterpreting TBUs in ABC+Q further highlights these parallels. By defining TBUs on the basis of phonological similarity and proximity attraction (e.g., Wayment 2009; Sylak-Glassman 2014), tone mobility—for example, in consonant-tone interactions (see §3.1)—can be seen as motivated by the same phonological pressures that drive parasitic harmony systems in the segmental domain (e.g., Rose and Walker 2004). An optimizing grammar driven by phonological similarity and proximity attraction moreover extends beyond surface phonological alternations to (stable) lexical patterns (e.g., Frisch et al. 2004; Coetzee and Pater 2008; et seq.). We have shown that ABC+Q predicts the inventory of lexical tone melodies (in addition to surface tone patterning) in the tonal domain (see §4.4). Such an approach parallels the ABC+Q and contextual markedness approaches to morpheme structure constraints (e.g., Hansson 2001; Rose and Walker 2004) and phonotactics (e.g., Hayes and Wilson 2006; in ABC, see e.g., Inkelas and Shih 2014).

Naturally, the question has been raised in much of the previous ABC literature of whether these phonological processes—local versus long-distance, assimilation versus dissimilation, vowel harmony versus consonant harmony versus string-to-string copying versus tone assimilation—should be united under a single analysis, be it ABC, AP, or another approach (e.g., Hyman 2012). Some have argued that typological differences (e.g., local versus long-distance spreading) indicate differences in underlying processes that should be ascribed to separate phonological models (Hansson 2001, 2010b; Rose and Walker 2004; Gallagher 2008; Gallagher and Coon 2009; Bennett 2013; a.o.). Others, both from the ABC and AP perspectives, have argued that typological differences should arise not out of distinct grammatical mechanisms but instead from the limited flexible variation predicted by the grammar itself (Jurgec 2013; Shih 2013; Inkelas and Shih 2014). In the comparison of tone and segmental phenomena specifically, it is clear that tone pushes the boundaries of what segmental phonology can do: namely, tones are significantly more "autosegmental" than segmental features (see Hyman 2011). Tones exhibit both more mobility and stability, at much longer distances, than segmental features. For example, a local segmental analogy to tone plateauing that avoids marked tonal troughs (e.g., H.LH → H.H; see §4.1; see also e.g., Cahill 2007) is gemination, in which featural plateaus—i.e., geminates—are created from short vowel syncope in the environment of two homorganic consonants (e.g., Odden 1988):

(28) Telugu (Dravidian, India) (example from Odden 1988:463, following Krishnamurti 1957)

/peru**ku-k**ō/	→	peru**kk**ō	'pull it out for yourself'
/nā**ṭ-aṭ**am/	→	nā**ṭṭ**am	'planting'
/ceru**ku-g**aḍa/	→	ceru**gg**aḍa	'sugarcane stick'

However, long distance tone plateauing can also occur, and segmental parallels are not as readily apparent (see Hyman 2011:218–219 for one potential long-distance example of vowel height plateauing in Yaka). This degree of difference—that tone is even more autosegmental—begs the question of whether tone is governed by distinct grammatical mechanisms from segmental phonology.

Ultimately, we believe that this issue must be empirically resolved, by better understanding how phonological patterns in segmental and suprasegmental domains play out in natural language and how these patterns are grounded in substantive and cognitive bases. For instance, the greater mobility of tone may be rooted in either operational differences—i.e., spreading versus agreement—or phonetic differences—i.e., that segments that are capable of transmitting F0 information are more common and frequent in the speech stream than segments that can maintain certain featural contrasts (e.g., not every segment can remain [+cont] while harmonizing for [+nas], so possible hosts for [+cont] agreement will be naturally less common). Applying a single framework to both tone and segmental phenomena is the best way to highlight whether observed behavioral differences between the phenomena are differences in degree, or differences in type of behavior. We look forward to future research which will push ABC+Q to account for even more esoteric and apparently tone-specific phenomena than what we have been able to cover here, illuminating further the question of whether tone really is different, or to what extent its behavior is, like that of segmental features, governed by the same basic principles of interaction under conditions of similarity and proximity.

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